Design and implementation of a deception jamming system for laser receivers

Conference Paper · March 2016

DOI: 10.1117/12.2206011

3 authors:

Ahmed S. Bahgat
Polytechnique Montréal

Ashraf F. El-Sherif
Military Technical College

Yasser H. El-Sharkawy
Military Technical College

Design and Implementation of a Deception Jamming System for Laser Receivers

Ahmed Sami Bahgat*, Ashraf F. El-Sherif and Yasser H. El-Sharkawy.
Military Technical College, Cairo, Egypt.

ABSTRACT

Laser jamming has two forms: passive and active jamming. In this paper we compare between the passive, active and passive-active deception techniques from the functional point of view. Passive jamming techniques are used with highly absorptive or diffusive materials on the body of the equipment. These passive techniques decrease the intensity of the reflected laser pulses and hence decrease SNR. Active jamming techniques are used to deceive and puzzle laser receivers. A high energy pulse with delay time is transmitted with each reflected pulse then the receiver will confuse between the two pulses. Active jammers need higher energy pulses to provide high jammer to signal ratio. In this paper we will compare received pulses using passive technique only, active technique only and passive-active technique. We use Q-switched Nd:YAG Laser source with wavelength of 1064 nm, energy of 80 mJ, pulse width of 200 µs and repetition rate 10-20 Hz. The intensity of the incident laser pulse is reduced by a factor of 80 % using an absorptive material, at the same time an electronic circuit receives the laser pulses and use it to trigger high-power LEDs with the same laser wavelength that make phase shift and signal distortion to the received pulses. The results show that the passive-active technique is the optimum one and solve the two disadvantages of each passive and active technique as individual. It decreases the reflected signal amplitude and hence the jammer to signal ratio can be obtained with lower power sources and increases the complexity for the DSP-based systems.

Keywords: High power LEDs, Laser jamming, Passive jamming, Cross correlation

1. INTRODUCTION

Today, owing to the superiorities such as high-precision guidance effect, strong anti-jamming capabilities, structural simplicity as well as low cost laser-based applications have become a major interest of research and development in many countries. This ever-increasing threat from lasers in many applications has spurred dramatic developments in laser deception sources that affect the function of laser receivers. Laser deceptive jamming is designed to deceive and puzzle enemy laser rangefinders and laser-guided weaponry using their own laser jammers. At present, large numbers of passive laser jamming equipment have been developed. Similarly, active laser jamming equipment and laser blinding techniques have also been put into use actually in beginning to display their powerful performance.[1-5]

Passive deception has several main techniques such as coatings with absorptive materials, adhering of absorptive polymers to the body of the equipment and manufacturing of the body using materials that has diffusive surface or absorptive property. The absorptive material can be classified into two categories, namely paint and structural type. Paint can be used to paint the surface of a target or adhere to the surface of a target. To construct the structural type, a non-metal base material is made into a honeycomb shape or ripple shape, which is then coated with wave-absorbing material; or wave-absorbing fiber is incorporated into these structures. Technically, the equipment is coated with a particular paint to make its surface brightness get dull and become a diffuse reflecting body reducing laser backward-scattering and enhancing diffuse reflection. Some fixed or semi-fixed targets, among other treatments, can be covered with a miniature cavity structure so that incident laser will be reflected back after repeated refraction and reflection in the cavity.

Active deception has two approaches can be applied in realizing deceptive jamming of laser receivers. One approach is as follows: when irradiated by a laser signal, transmitting (or reflecting), in a very short delay time, a signal with the same wavelength and pulse width is generated along the original path so that the laser receiver will mistake one target with two targets. The other jamming approach is re-transmitting the laser pulse after a delay period so as to enlarge the error in the laser receiver operations.

*a.s.bahgat48@gmail.com; phone +201099457661

Light-Emitting Diodes: Materials, Devices, and Applications for Solid State Lighting XX, edited by Heonsu Jeon, Li-Wei Tu, Michael R. Krames, Martin Strassburg, Proc. of SPIE Vol. 9768, 97681M · © 2016 SPIE
CCC code: 0277-786X/16/$18 · doi: 10.1117/12.2206011

In this paper we introduce a method for deception using both passive and active deception techniques. A polymer sheet is used to absorb the intensity of the incident laser beam by more than 90% .Laser detection system is used for detecting, filtering, conditioning and delaying the laser incident pulses and use it to drive high power NIR LEDs. The reflected beam is superimposed with optical signal produced from LEDs with wavelength band covering the laser source wavelength that act as a repeater of the incident laser with certain small delay relative to the pulse width. Also the research seeks to present post-integration processing in order to improve the sensitivity of electronic support measure receivers. Correlation methods take advantage of the periodic character of received signals. In such cases, autocorrelation and cross-correlation improve the detection of signals with high repetition frequency. The purpose of such a method is to recognize a prior know signal in the received noisy signal.

2. EXPERIMENTAL SETUP

The experimental setup illustrated in Figure 1, consist of Q-switched Nd:YAG Laser source with wavelength of 1064 nm, energy of 80 mJ, pulse width of 200 µs and repetition rate 10-20 Hz. The laser pulses are interacts with the metal target. The scattered signals was processed using receiving system after collected by collimating thick convex lens with aperture 5cm and a focal length 10cm. The received signal after analogue signal conditioning is fed to a decision circuit that is used to capture the repetition code of the incident signal and generate the same code with certain delay to trigger HPLEDs array (high power light emitting diodes) through constant current driver.

Finally we measure and analysis the scattered signal from the metal target ,the metal target coated by passive jamming material, the metal target and active jamming, and finally metal target coated by passive jamming material and active jamming.

HPLEDs array that consist of GaAs 60 LEDs chips with peak wavelength of 1070 nm, half width of 55 nm, Optical Output power of 60 mW and forward current of 0.6 A, is used as active jammer. The passive jammer is an absorption chemical polymers that has high attenuation coefficient for wavelength of 1064 nm as shown in Figure 2 (measured using FTIR technique).

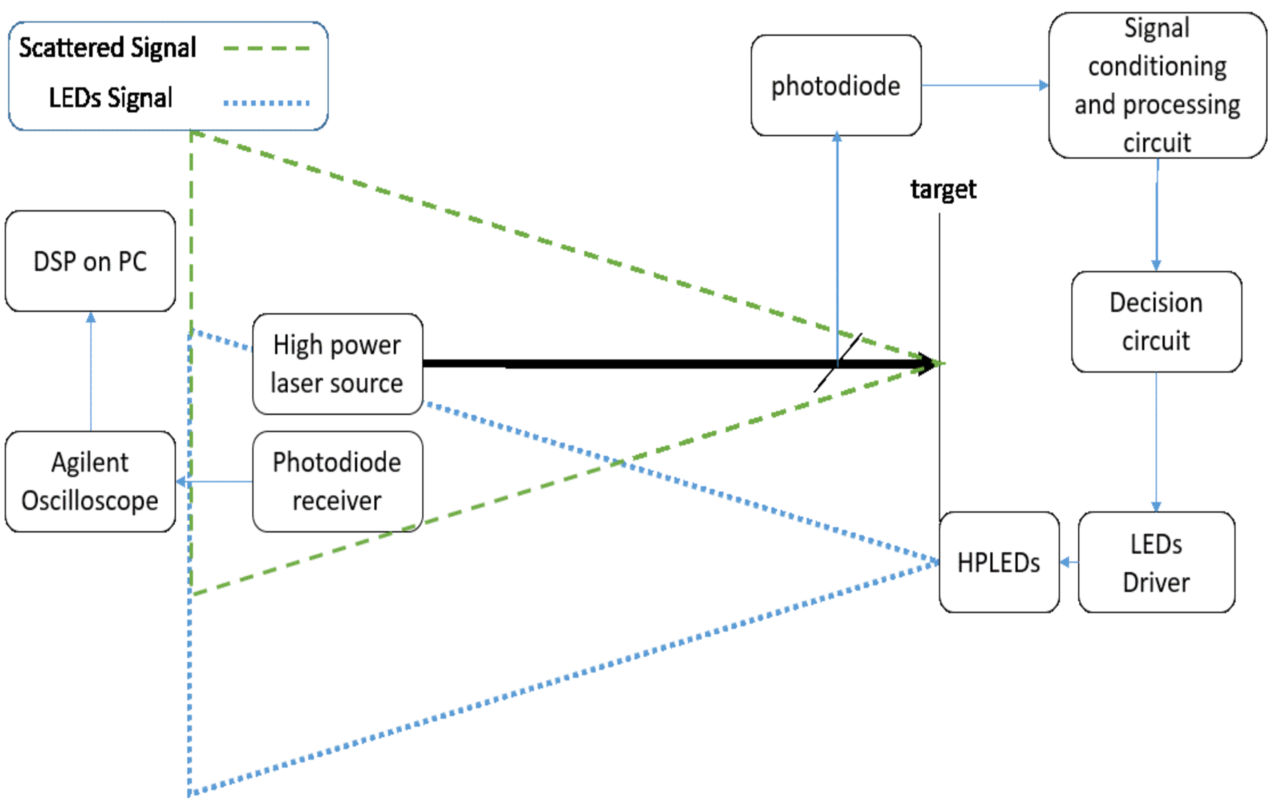

Figure 1. Block diagram of passive-active deception jamming system.

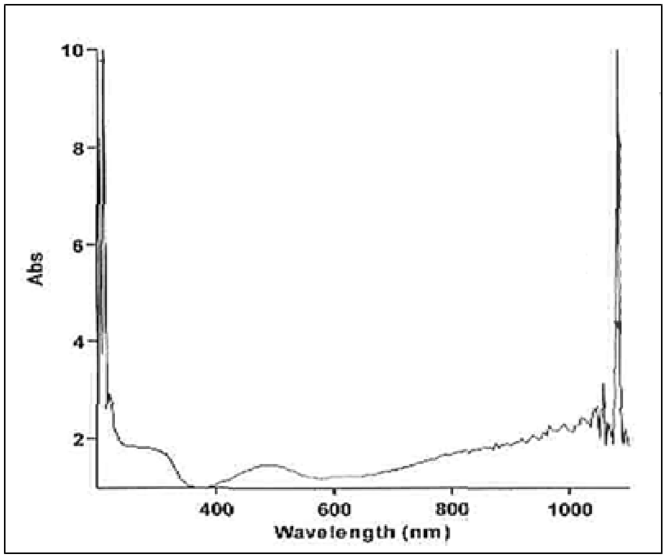

Figure 2. Absorption curve of used chemical polymer.

As mentioned before, the procedure of the measurement first a metal target is used and the HPLEDs array system is off, the captured signal is the reference signal. Second we kept the metal target and the HPLEDs Array is on and captures the signal. Third the passive jamming polymer cover the metal and HPLED array are off. Forth the passive jamming polymer cover the metal and HPLEDs array are on. The data is analyzed using Cross-correlation for the purpose of such a method is to recognize a prior known signal in the received noisy signal.

3. RESULT AND DISCUSSION

3.1 Passive deception jamming

The results obtained are shown in Figure 3, when the transmitted pulse is reflected from the metal target (reference) in channel 1 and the scattered from passive jammer in channel 2. Figure 4 shows the received signal after processing and calculate the correlation and power estimated between the reference and the passive jamming.

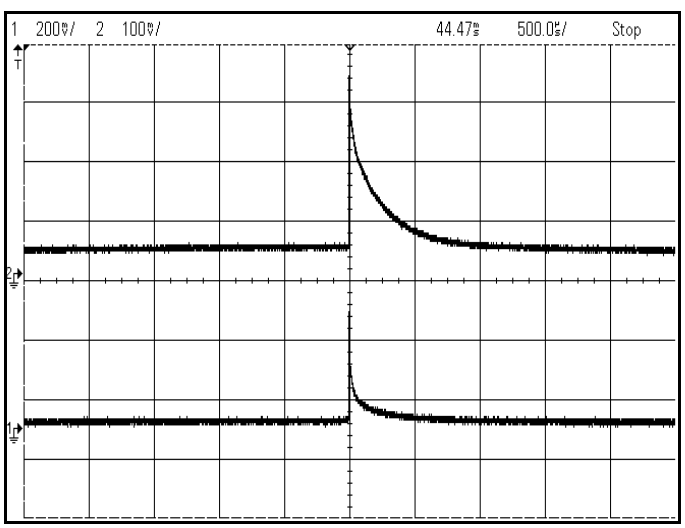

Figure 3. The echo signal from passive target and the HPLEDs are off vs reference signal.

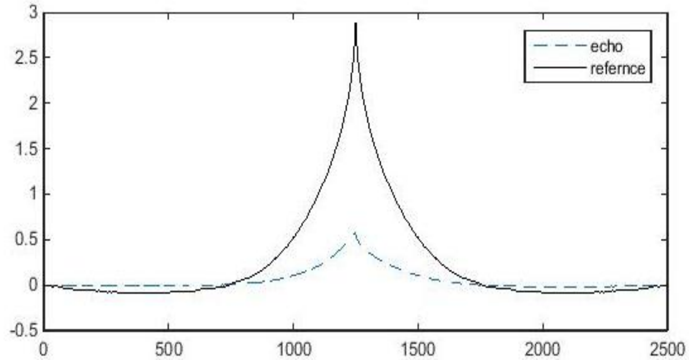

Figure 4. Cross correlation result of reference signal and echo signal from passive target and HPLEDs are off.

3.2 Active deception jamming

The results obtained are shown in Figure 4, when the transmitted pulse is reflected from the metal target (reference) in channel 2 and the generated signal from active jammer in channel 1 are shown in Figure 4. Figure 5 shows the received signal after processing and calculate the correlation and power estimated between the reference and the active jamming.

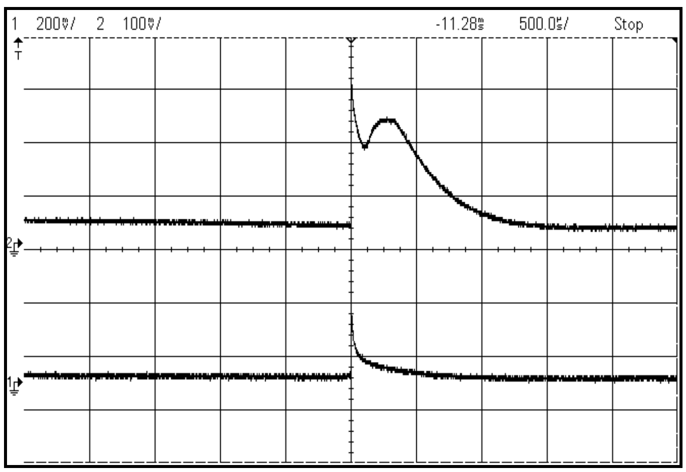

Figure 5. The echo signal from metal target and the HPLEDs are on vs reference signal.

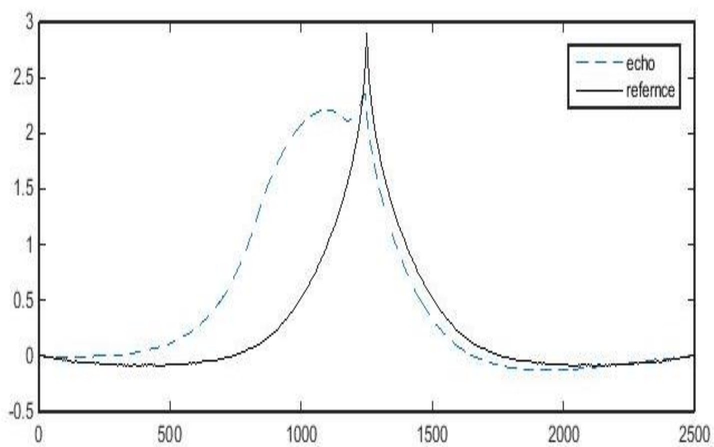

Figure 6. Cross correlation result of reference signal and echo signal from metal target and HPLEDs are on.

3.3 Passive-Active deception jamming

The results obtained are shown in Figure 7, when the transmitted pulse is reflected from the metal target (reference) in channel 2 and the generated signal from active jammer combined with the scattered signal from passive jammer in channel 1. Figure 8 shows the received signal after processing and calculates the correlation and power estimated between the reference and the active and passive jamming.

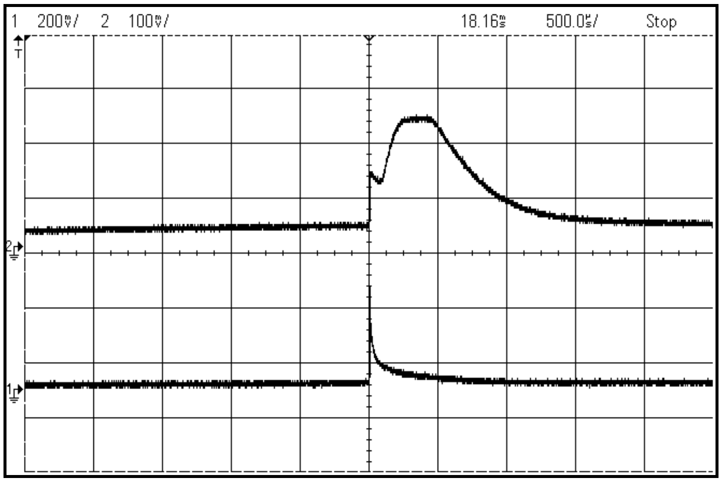

Figure 7. The echo signal from passive target and the HPLEDs are on vs reference signal.

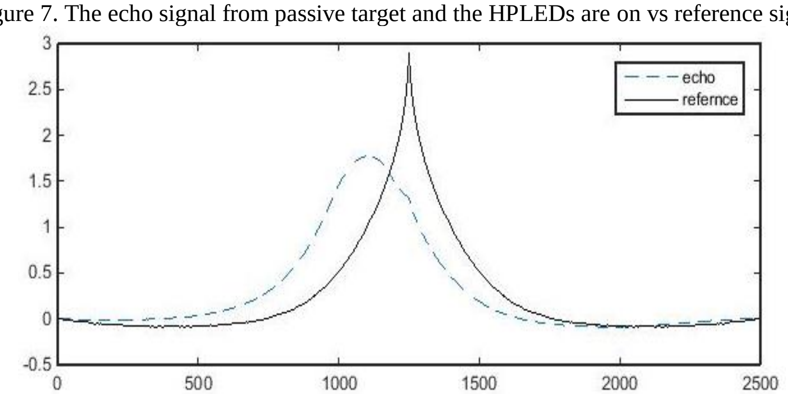

Figure 8. Cross correlation result of reference signal and echo signal from passive target and HPLEDs are on.

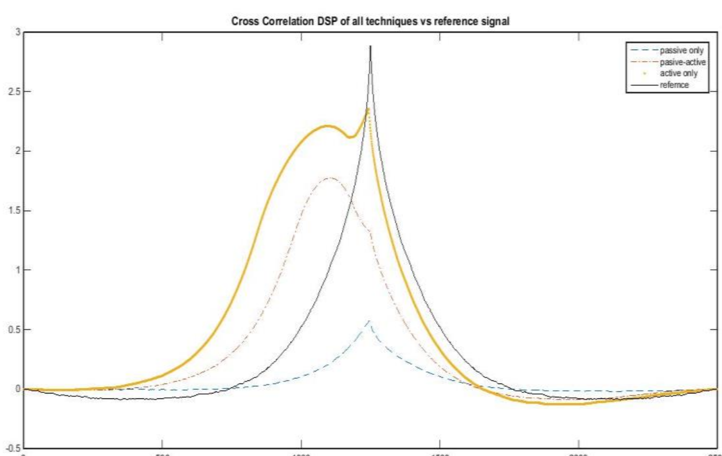

Figure 9. Comparison between cross correlation for all used technique vs reference signal.

Finally, it is clear from figure 9 that passive jamming deception can be easily detected if a simple algorithm of DSP is applied and the active technique can also be detected but in case of combined passive and active techniques the signal can't be detected and this is the aim of the paper.

4. CONCLUSION

Laser jamming has two forms: passive and active jamming. In this paper we compare between the passive, active and passive-active deception techniques from the functional point of view. In this paper we design an algorithm using cross correlation to compare between active, passive, and active-passive jamming. The results show that the passive-active technique is the optimum one and solve the two disadvantages of each passive and active technique as individual. It decreases the reflected signal amplitude and hence the jammer to signal ratio can be obtained with lower power sources and increases the complexity for the DSP-based systems.

REFERENCES

[1] Kashin, Valery, "Arena: Active Protection System for Tanks," Military Parade, May-June 1996.
[2] Bonsignore, Ezio and Ian Bustin, Towards "Electronic Armour," Military Technology, Dec. 1993.
[3] Danussi, Gerry, Captain, U. S. Army, National Ground Intelligence Center (NGIC) Analysts. Personal Interview, 16 Jan 1998.
[4] Ogorkiewicz, R.M., "Transforming the Tank," Jane's International Defense Review, Oct 1997.
[5] Hewish, Mark and Leland Ness, "Shoot First, Ask Questions Later: Smart Tanks Learn To Fend For Themselves," Jane's International Defense Review, Mar. 1996.